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(54) **HYDRAULIC MOTOR APPARATUS**

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(52) **U.S. Cl.** **475/83**; 60/489; 91/418

(58) **Field of Classification Search** 180/364,
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See application file for complete search history.

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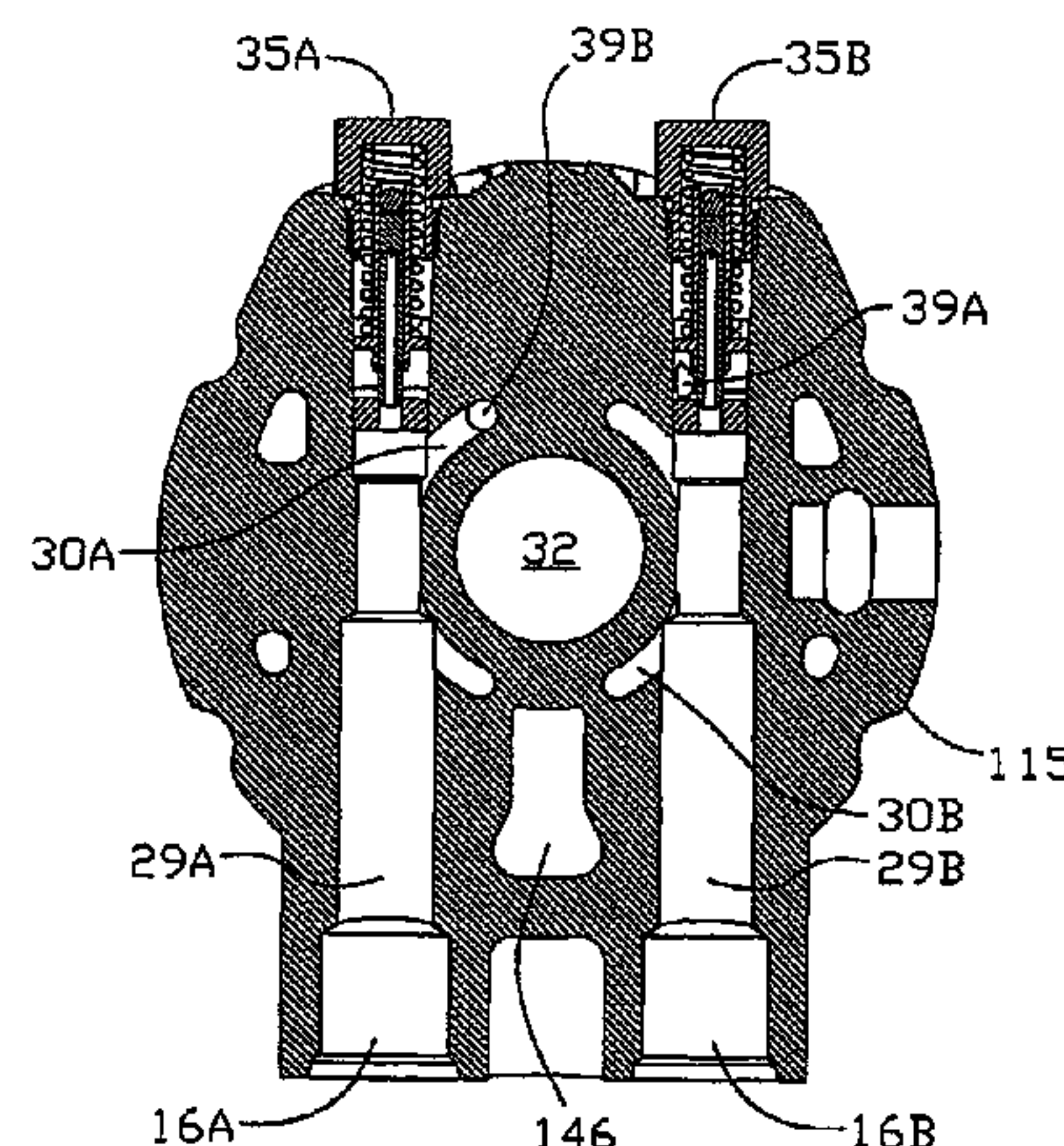
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(57)

ABSTRACT

A hydraulic motor assembly having a motor and gear reduc-
tion set mounted in a housing. The housing may be formed of
separate components, including the external surface of the
ring gear and the hydraulic motor port block. The motor
assembly may also include pressure relief valves or neutral
valves in the motor port block and a brake assembly mounted
in the port block or on the motor housing to provide braking
for the output axle.

17 Claims, 17 Drawing Sheets



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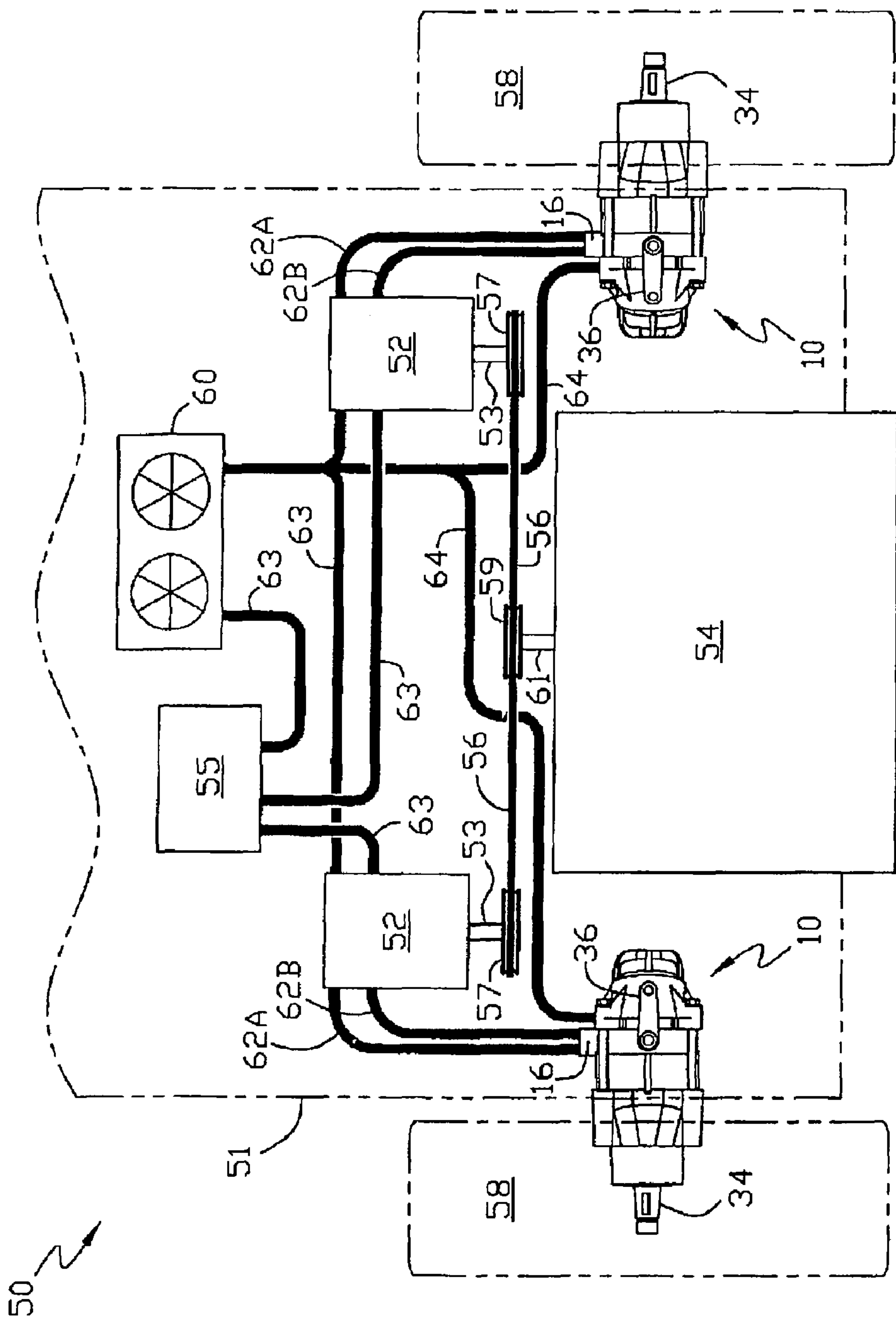


FIG. 1

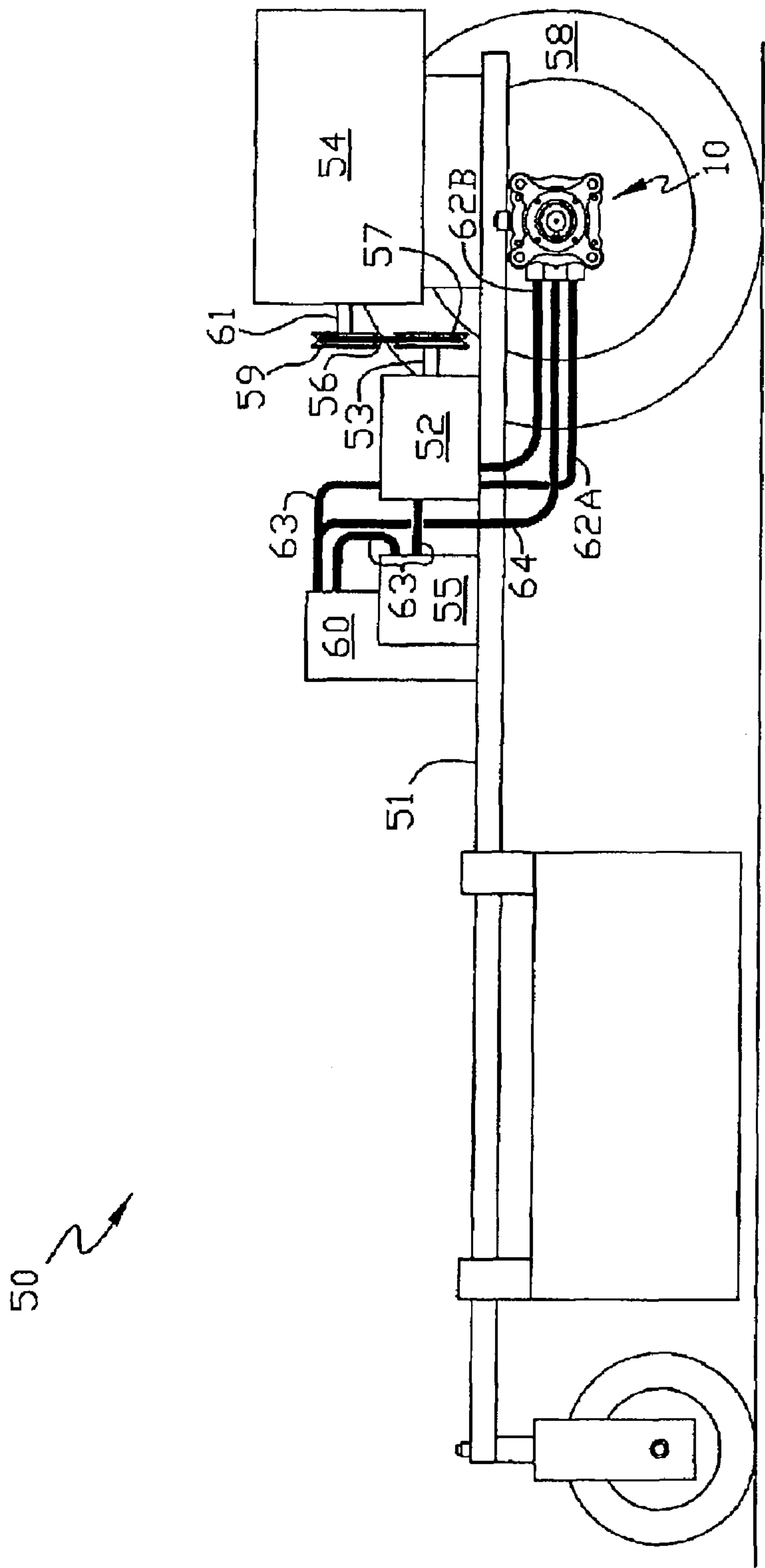


FIG. 2

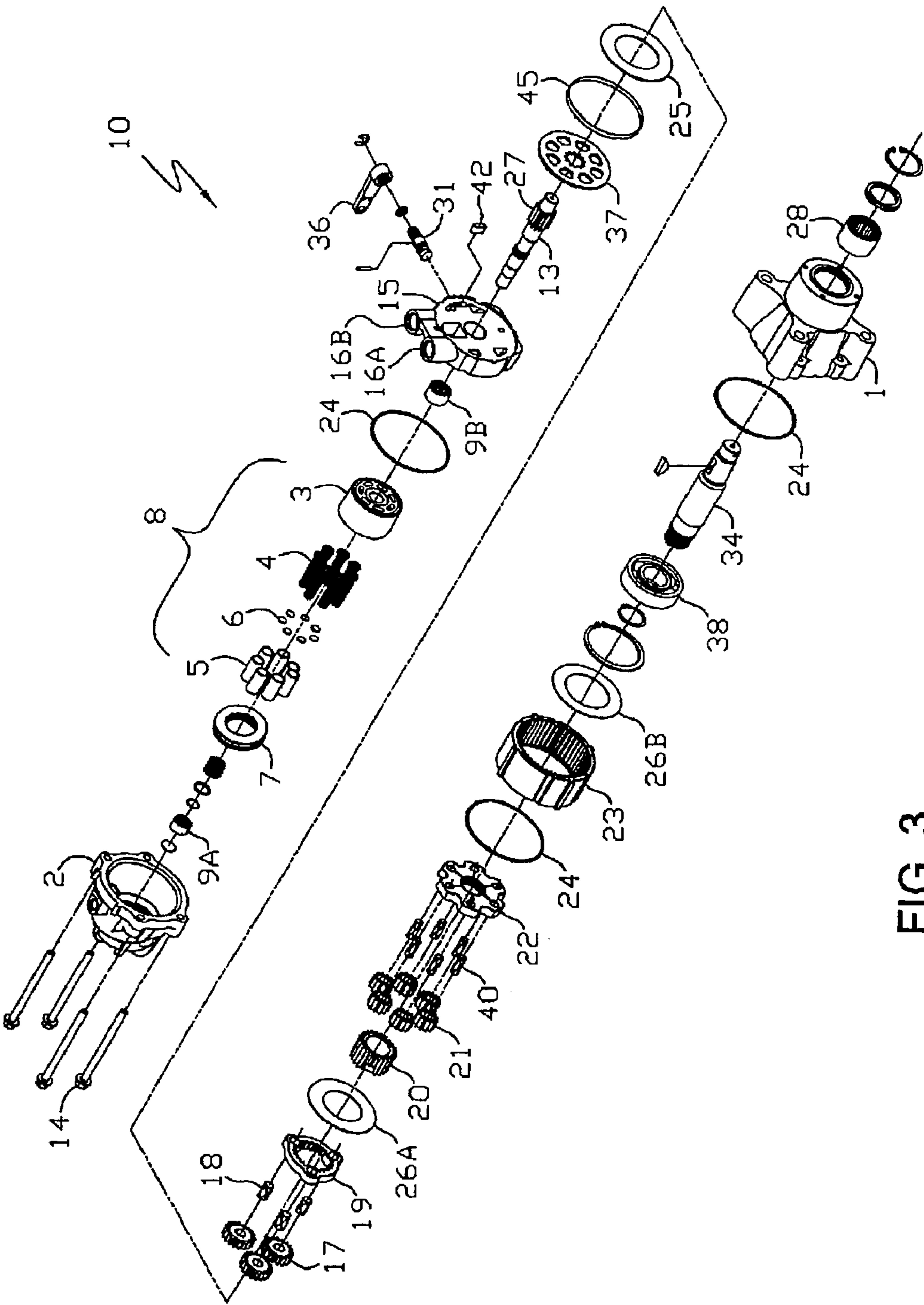


FIG. 3

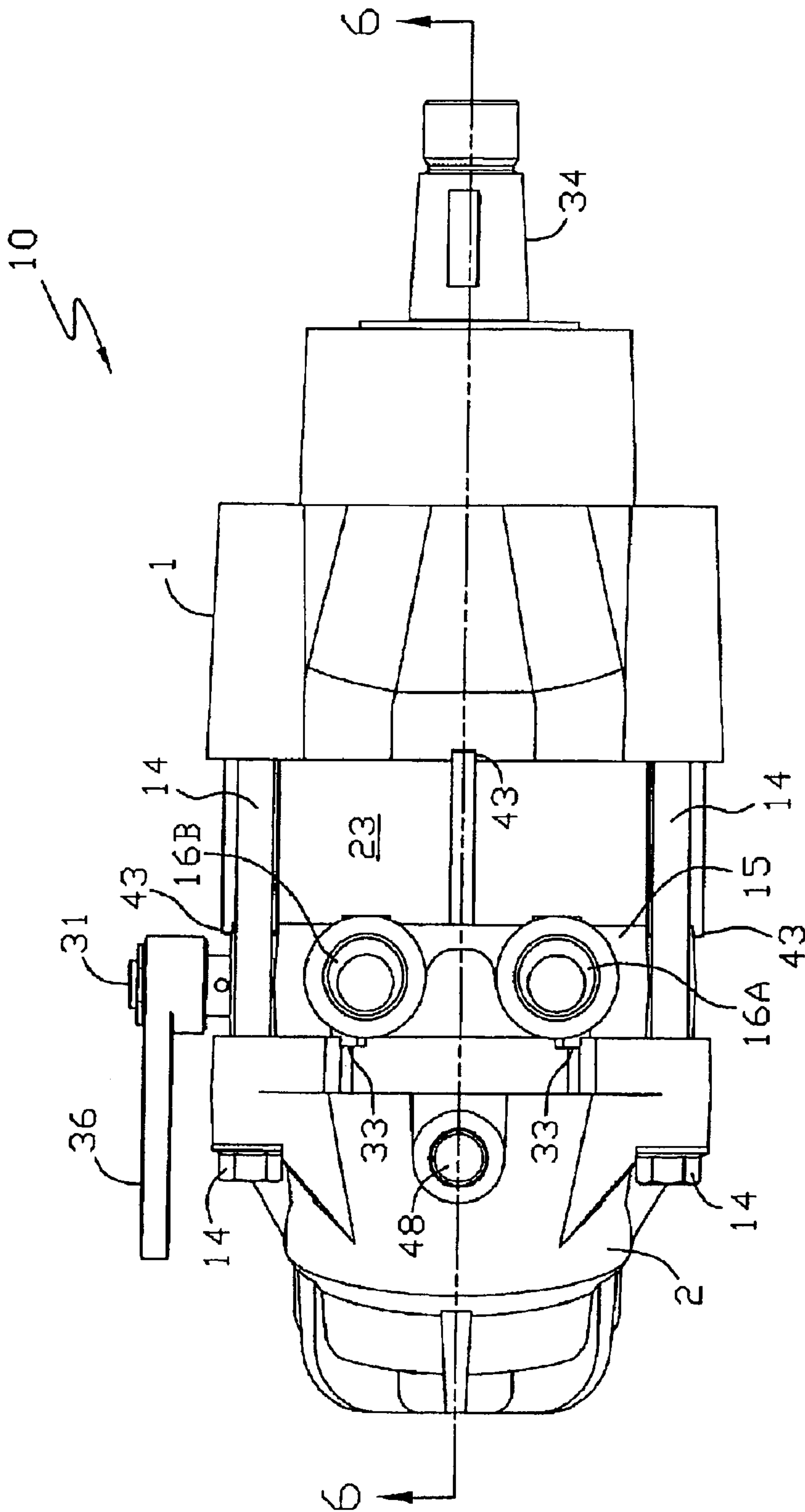


FIG. 4

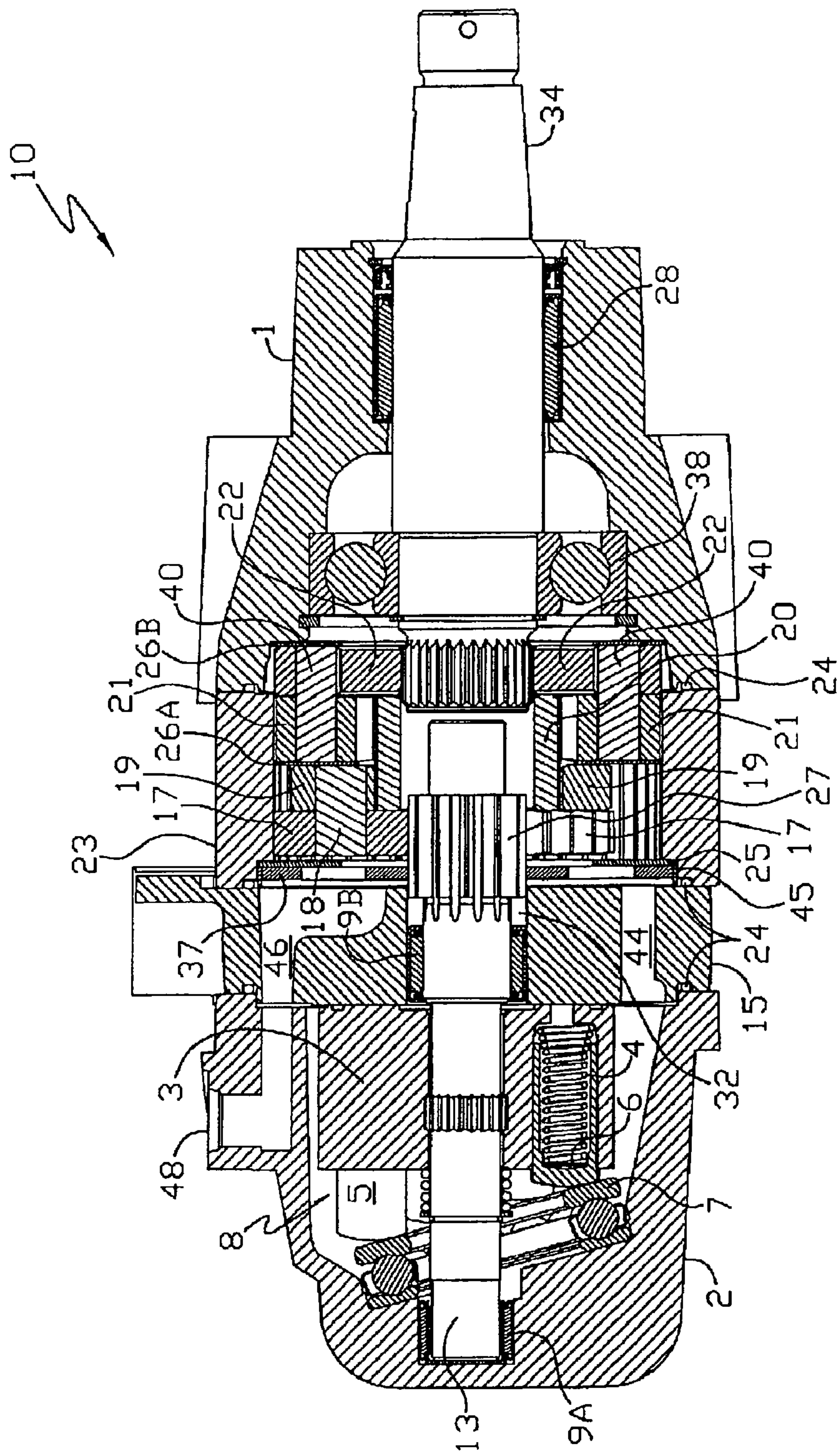


FIG. 5

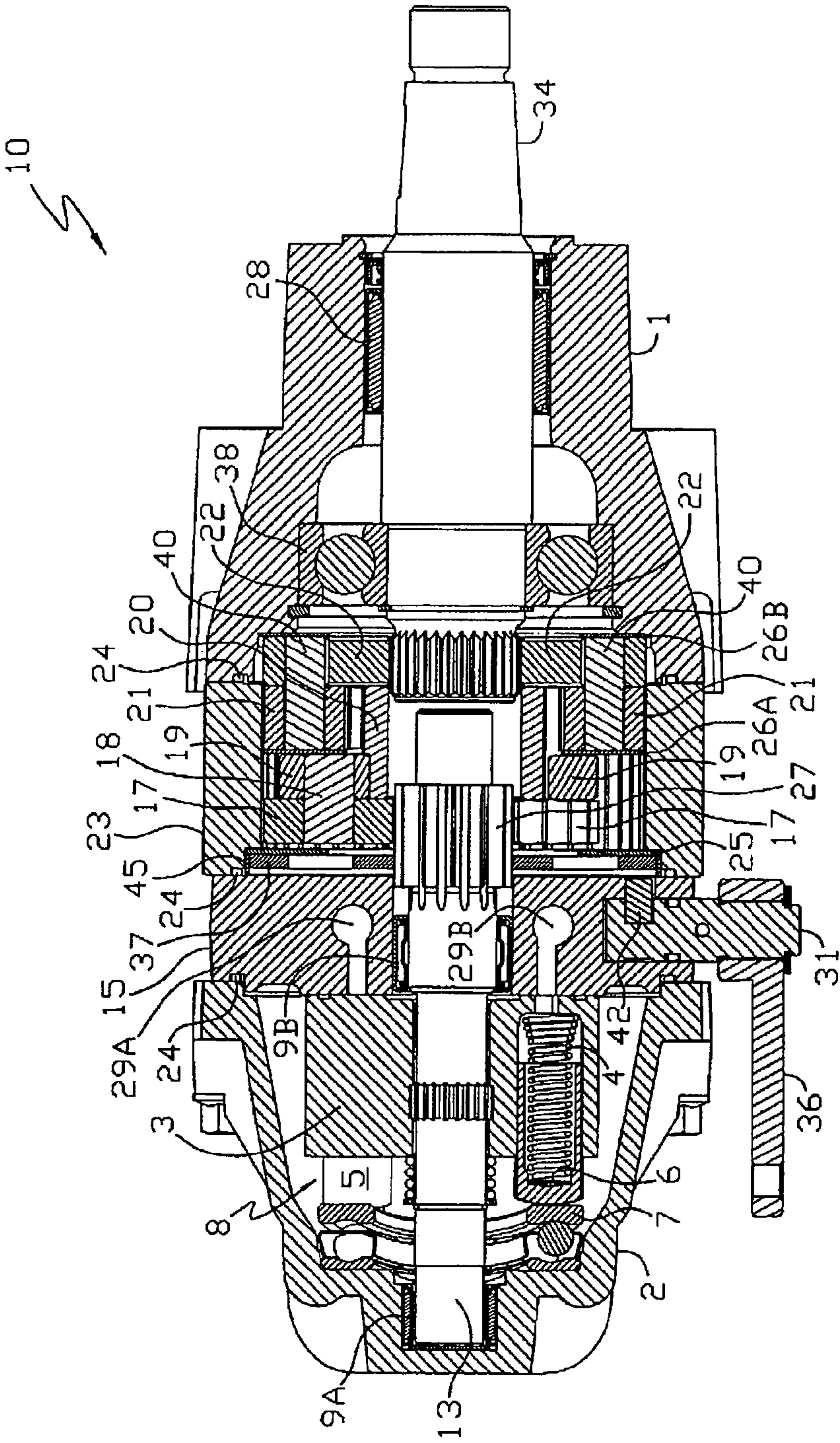


FIG. 6

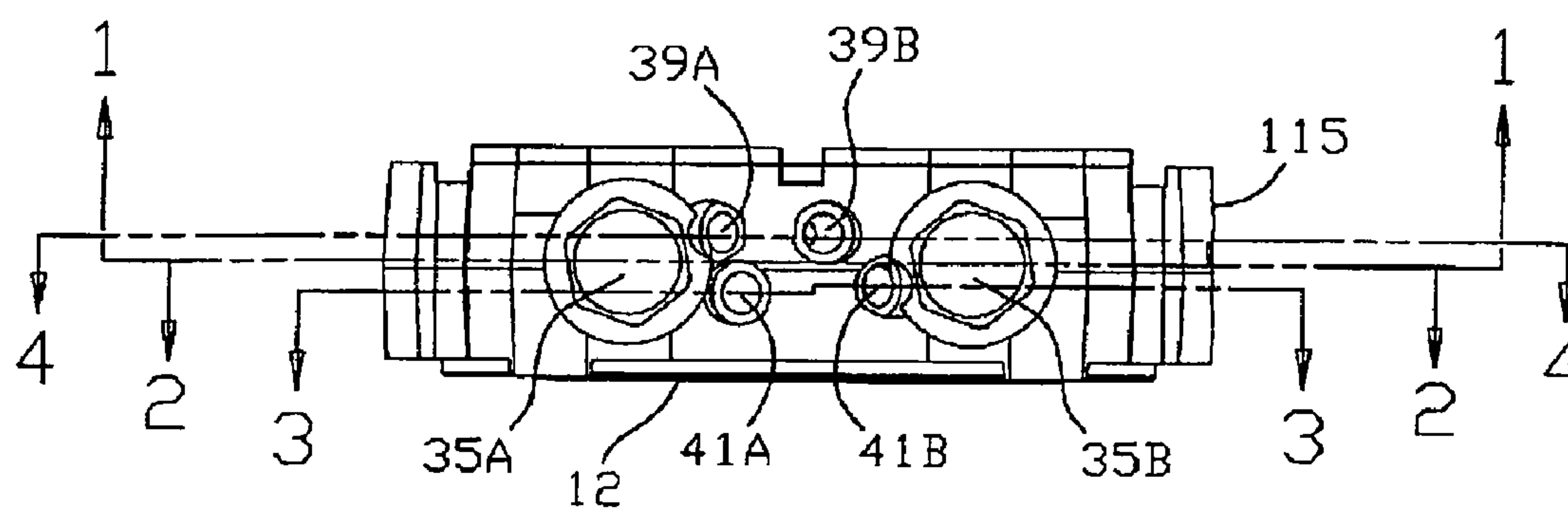


FIG. 7

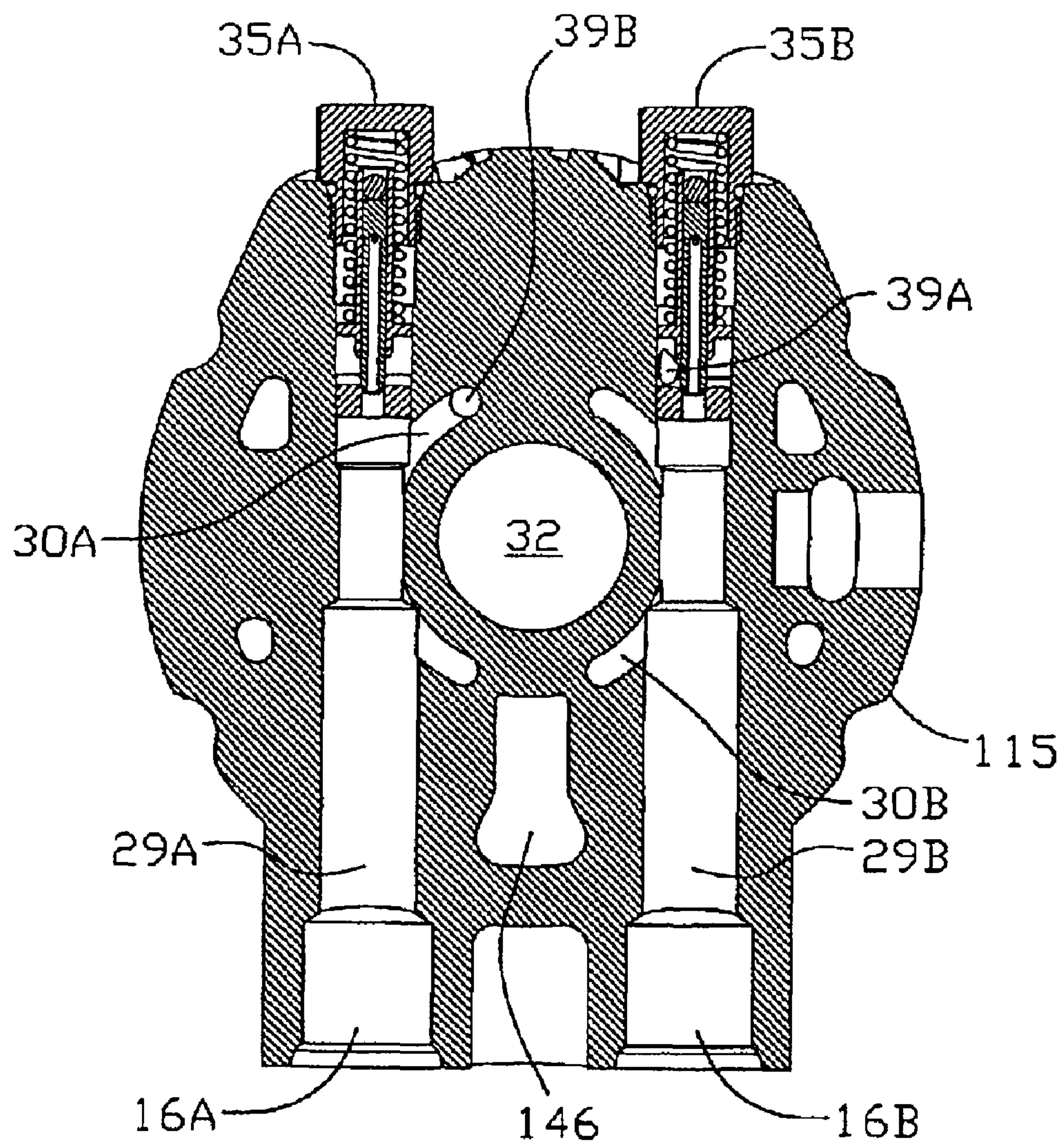


FIG. 8

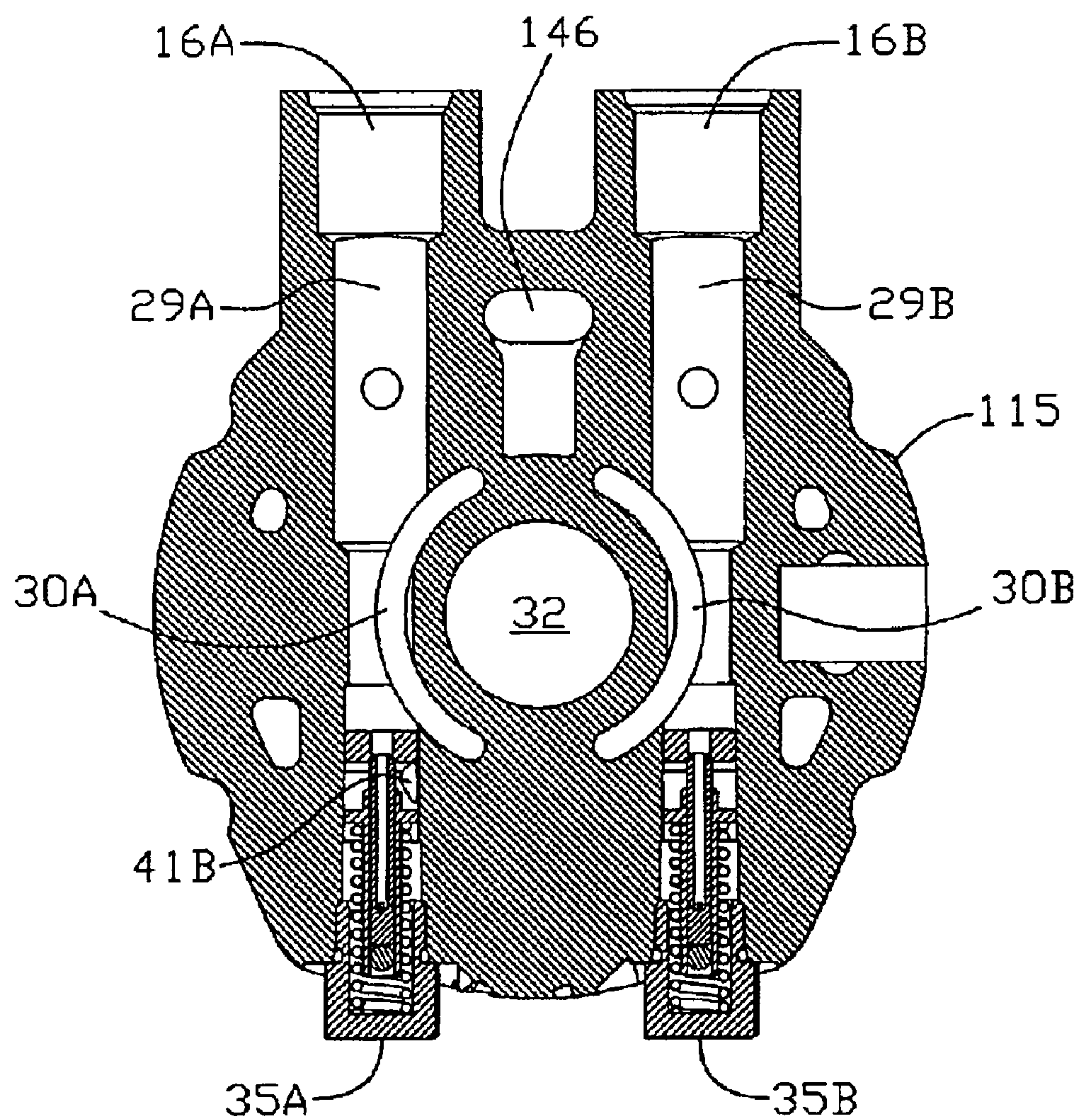


FIG. 9

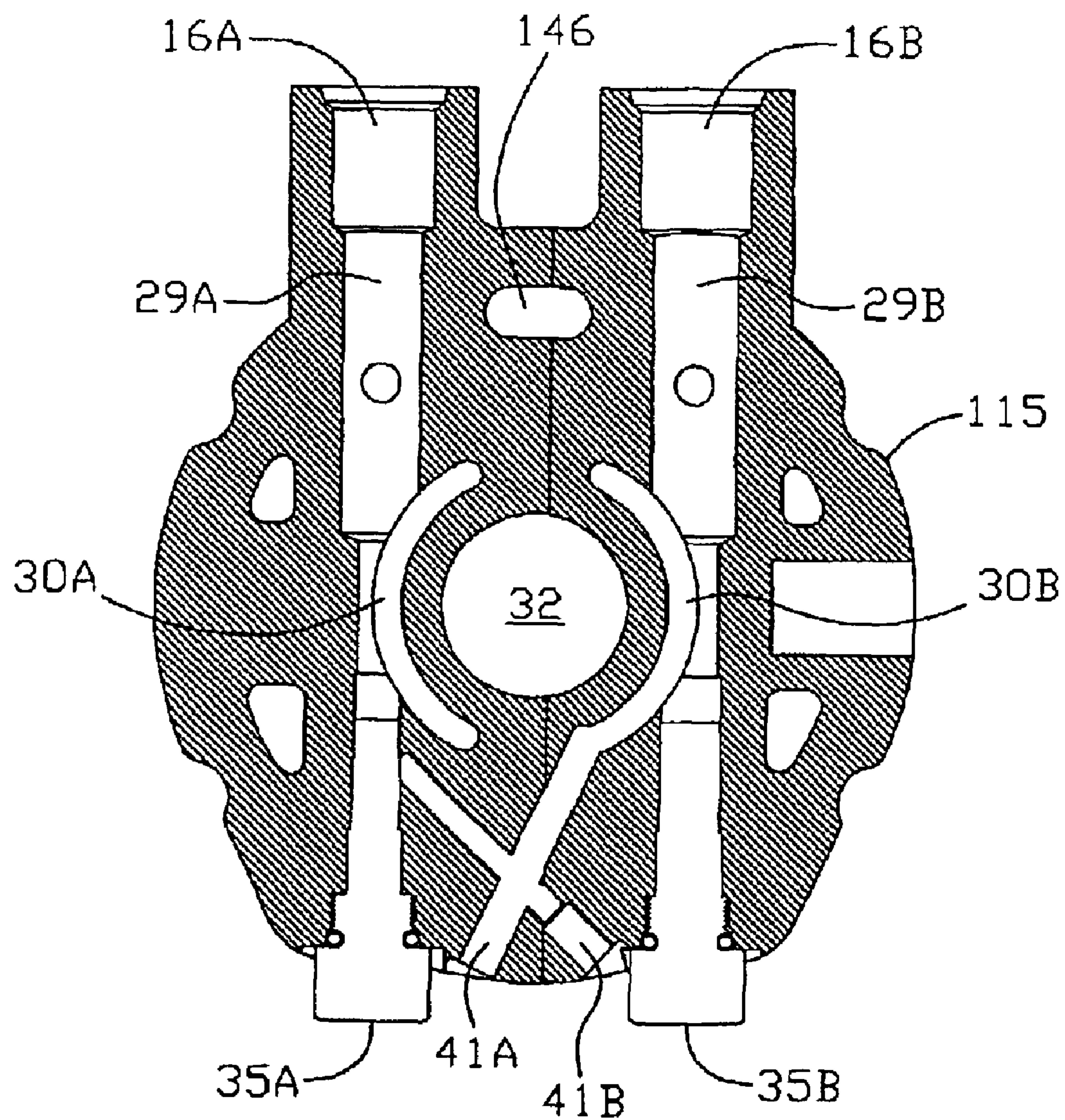


FIG. 10

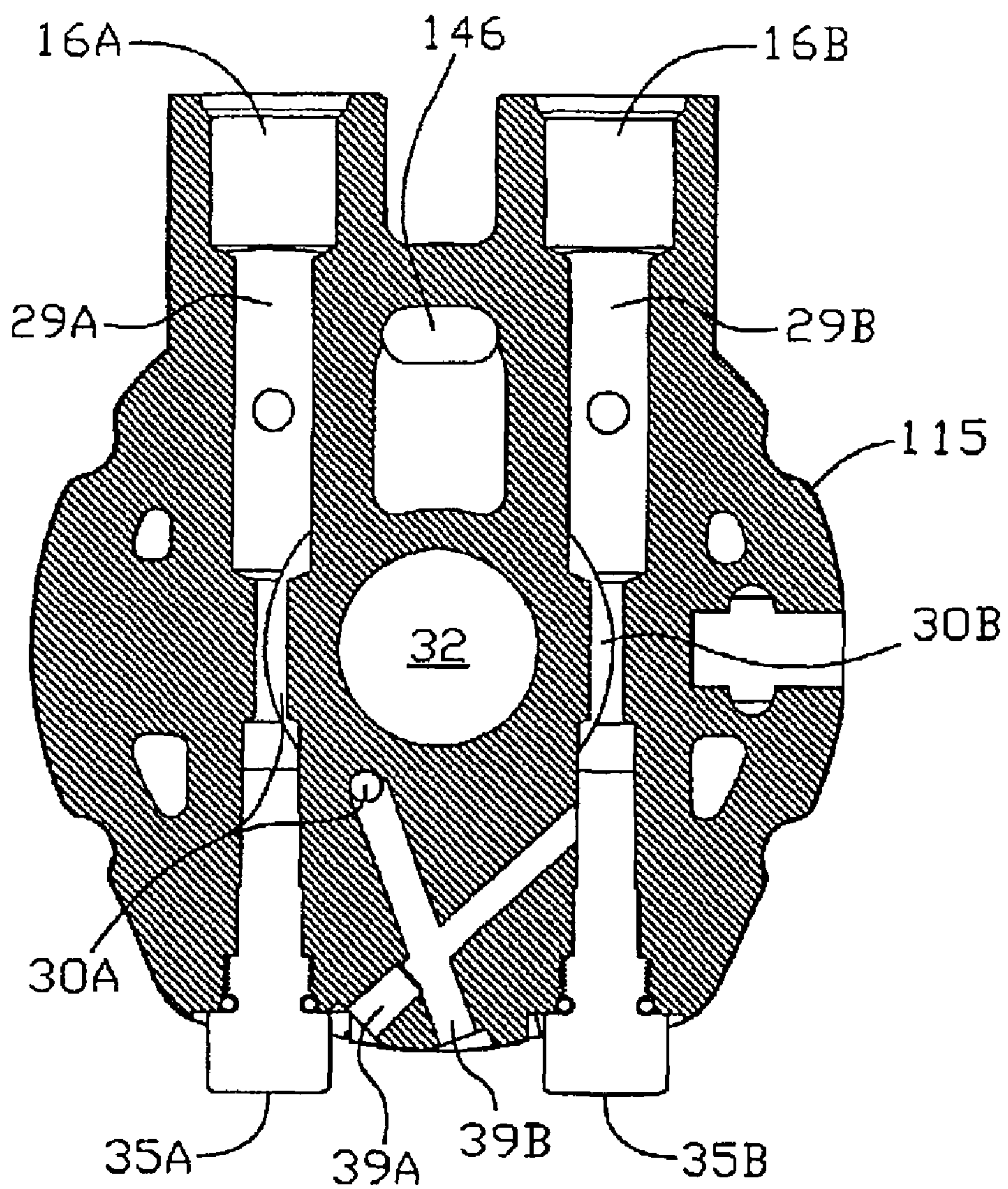


FIG. 11

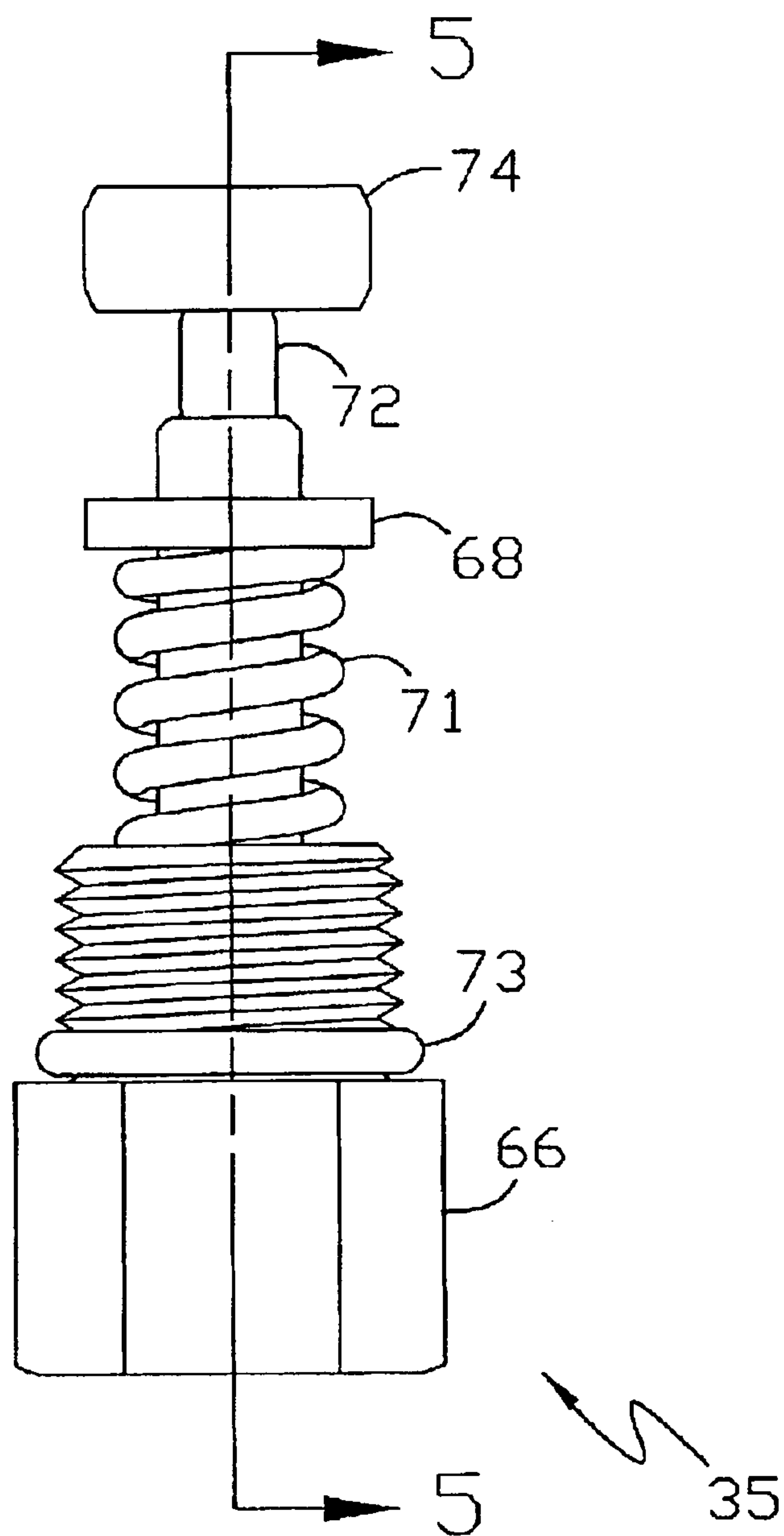


FIG. 12

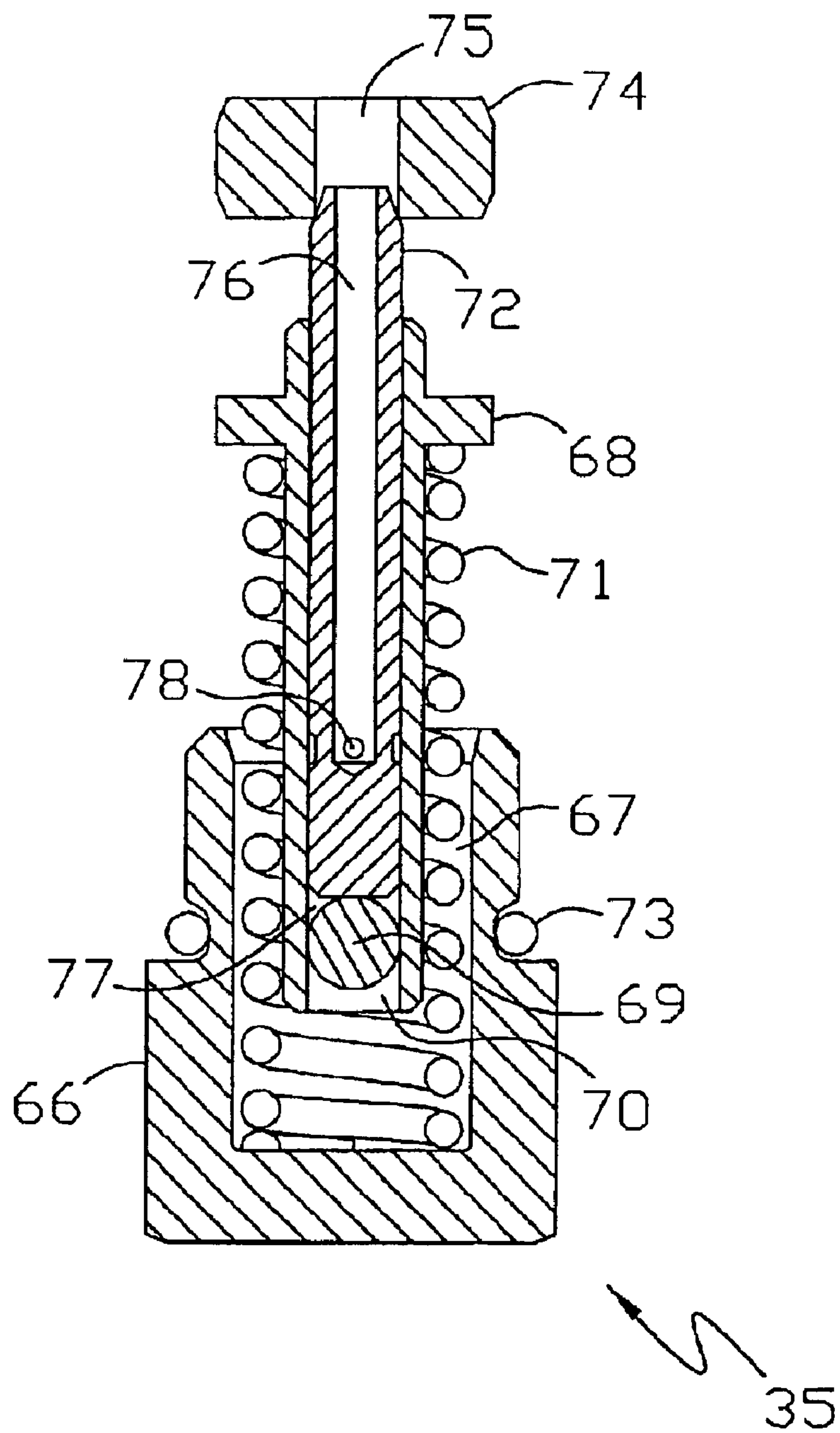


FIG. 13

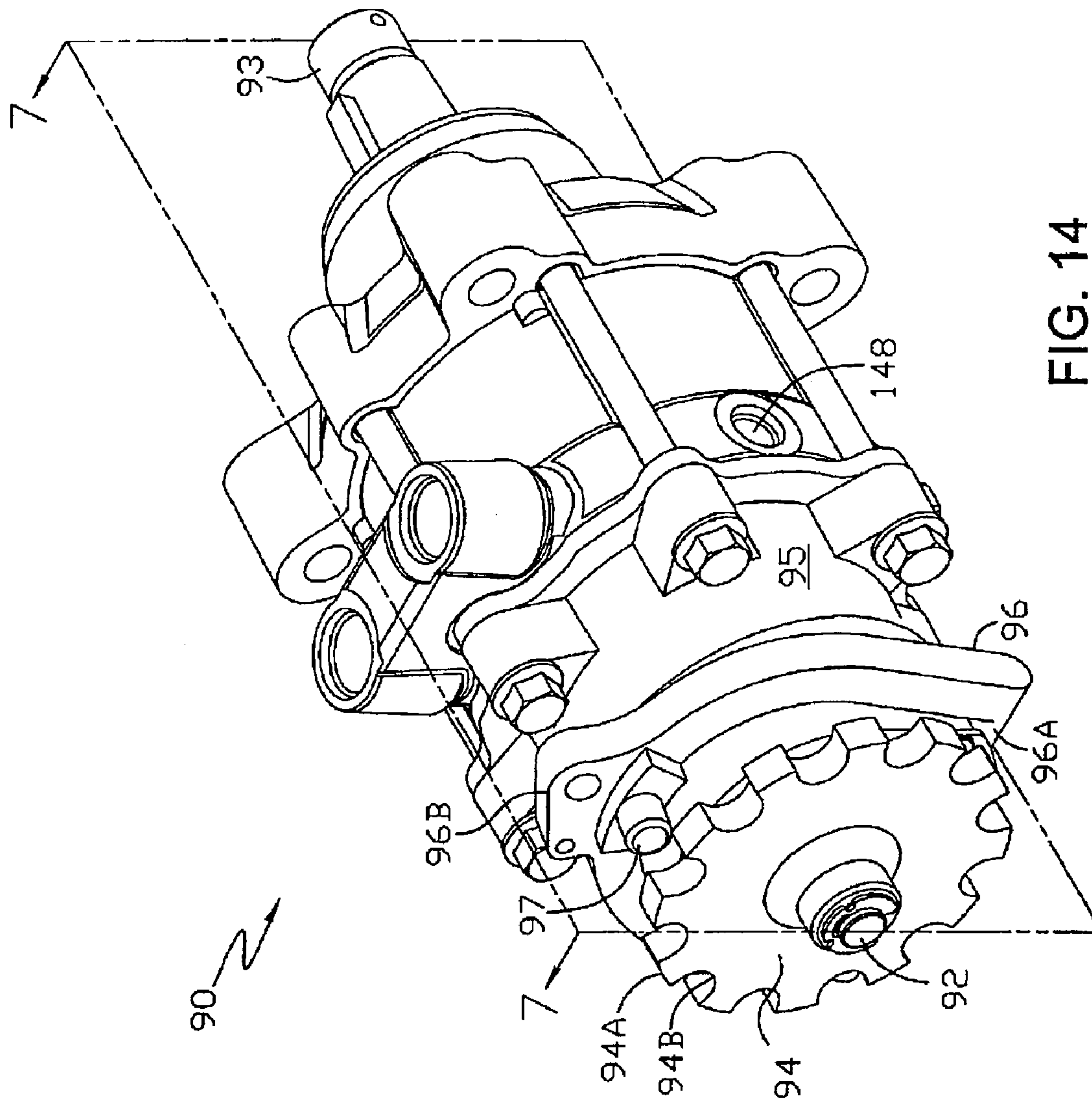


FIG. 14

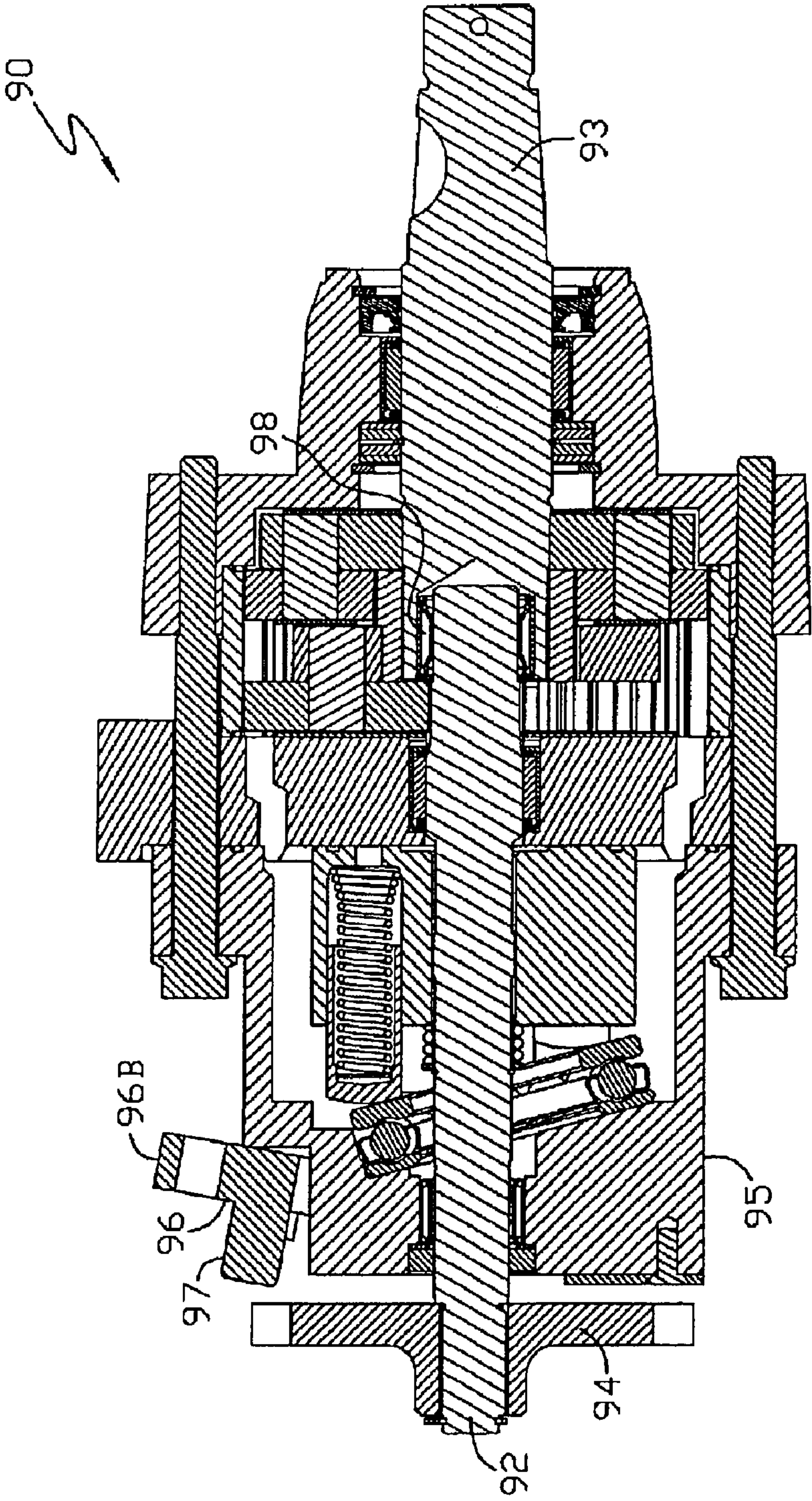


FIG. 15

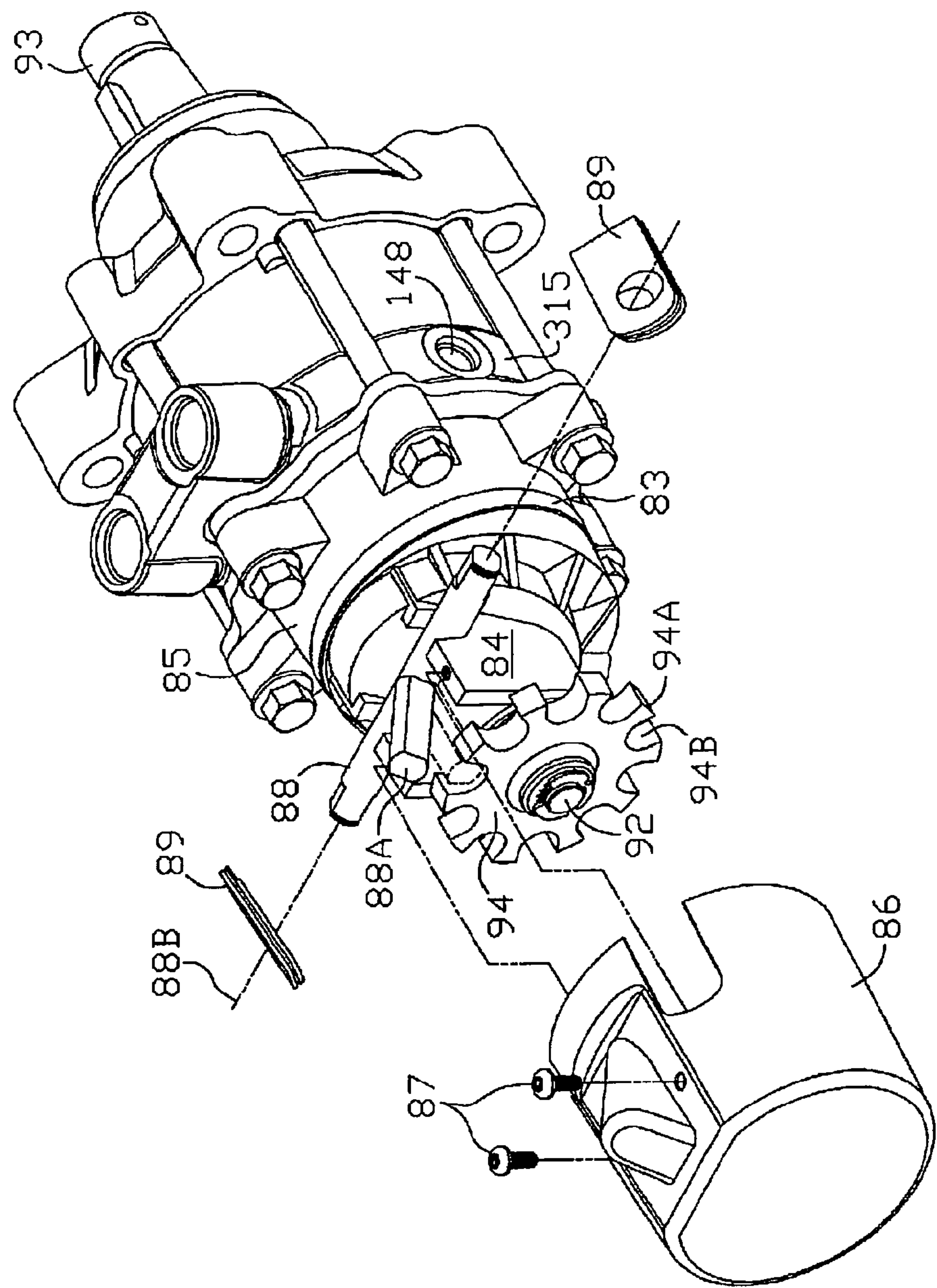


FIG. 16

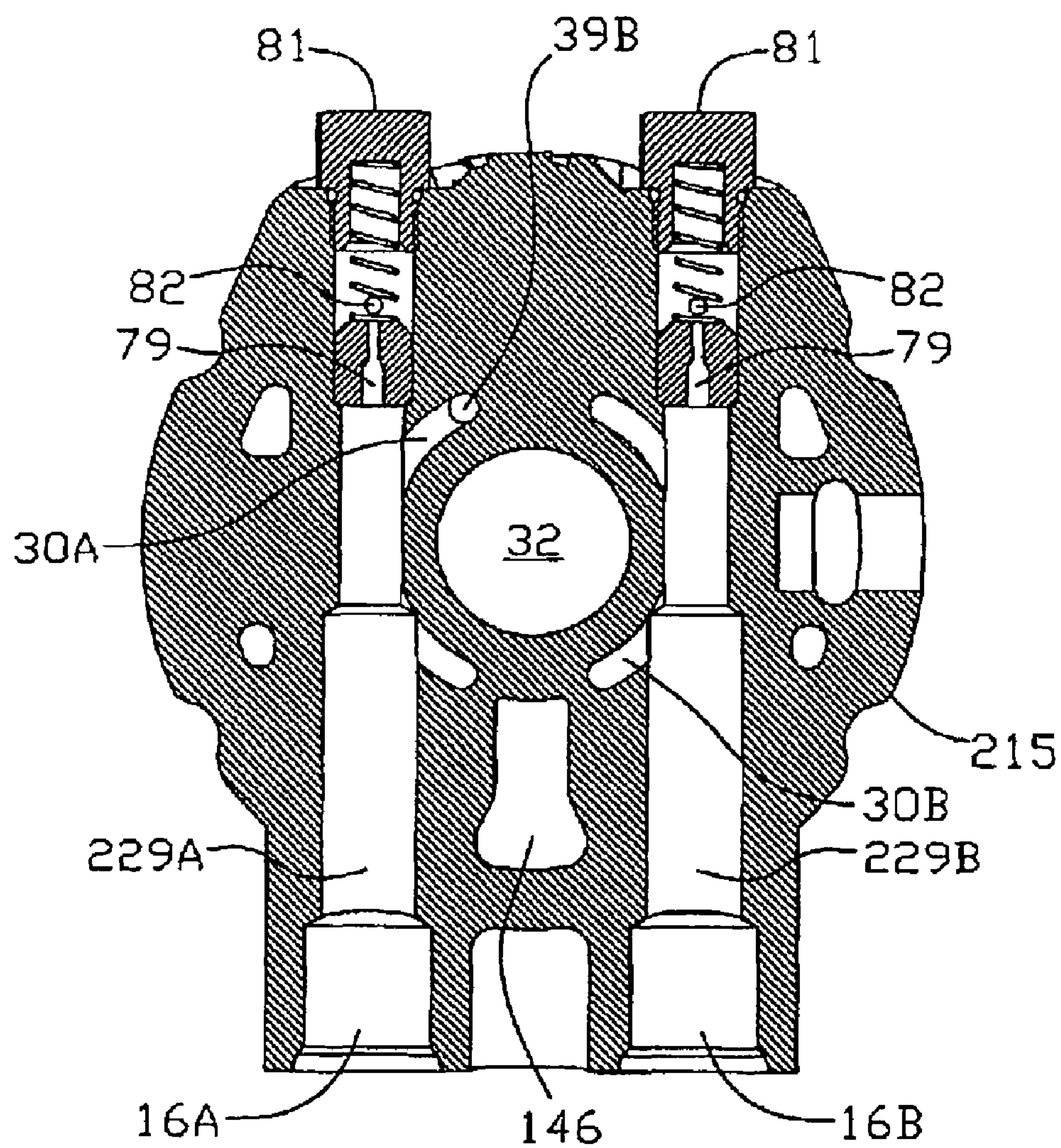


FIG. 17

HYDRAULIC MOTOR APPARATUS**CROSS REFERENCE TO RELATED APPLICATION**

This application is a continuation of U.S. patent application Ser. No. 11/003,757 filed Dec. 3, 2004, which is a continuation of U.S. patent application Ser. No. 10/260,981, filed Sep. 30, 2002, now U.S. Pat. No. 6,840,879, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/407,814, filed Sep. 3, 2002. These prior applications are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

This invention relates to hydraulic or hydrostatic motors for use in vehicles, industrial applications or other applications.

SUMMARY OF THE INVENTION

This invention discloses a hydraulic motor assembly having a housing in which the hydraulic motor, output axle and gear reduction set are mounted. This invention may be used in a variety of industrial and vehicle applications, especially those vehicles where a wheel motor is used. The invention also discloses the use of pressure relief valves and neutral valves in the hydraulic motor assembly.

A better understanding of the objects, advantages, features, properties and relationships of the invention will be obtained from the following detailed description and accompanying drawings which set forth an illustrative embodiment and is indicative of the various ways in which the principles of the invention may be employed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top partial schematic view of a vehicle incorporating the present invention.

FIG. 2 is a side schematic view of the vehicle incorporating the present invention.

FIG. 3 is an exploded view of the hydraulic motor assembly of the present invention.

FIG. 4 is a plan view of the hydraulic motor assembly shown in FIG. 3.

FIG. 5 is a cross-sectional side view of the hydraulic motor assembly shown in FIG. 3 along the lines 6-6 in FIG. 4.

FIG. 6 is a cross-sectional side view of the hydraulic motor assembly shown in FIG. 4, with the cross-section taken in the plane of the page of FIG. 4, through the center line of the shafts.

FIG. 7 is an end view of a second embodiment of the port plate of the present invention.

FIG. 8 is a cross-sectional view of the second embodiment of the port plate, along the line 1-1 in FIG. 7.

FIG. 9 is a cross-sectional view of the second embodiment of the port plate, along the line 2-2 in FIG. 7.

FIG. 10 is a cross-sectional view of the second embodiment of the port plate, along the line 3-3 in FIG. 7.

FIG. 11 is a cross-sectional view of the second embodiment of the port plate, along the line 4-4 in FIG. 7.

FIG. 12 is a plan view of the relief valve shown in FIGS. 7 to 11.

FIG. 13 is a cross-sectional side view of the valve along the line 5-5 in FIG. 12.

FIG. 14 is a perspective view of another embodiment of this invention.

FIG. 15 is a cross-sectional side view along the line 7-7 in FIG. 14.

FIG. 16 is a perspective view of another embodiment of this invention.

FIG. 17 is a cross-sectional view of another embodiment of the port plate.

DETAILED DESCRIPTION OF THE DRAWINGS

The vehicle 50 depicted schematically in FIGS. 1 and 2 is a zero turn vehicle using the two motor assemblies 10 as wheel motors to drive a pair of wheels 58. In FIG. 2, only one motor assembly 10 is shown for clarity. Vehicle 50 is powered by a prime mover such as engine 54, which drives pulley 59 through engine output shaft 61. A pair of pumps 52 are mounted on vehicle frame 51 in some known manner. Pump input shafts 53 are driven by pulleys 57 engaged to a belt 56 which are in turn driven by engine pulley 59. Pumps 52 are preferably of the axial piston design such as the Hydro-Gear BDP-10A, but other pump designs could also be used herewith. Hoses 62A and 62B are used to connect pumps 52 to inlets 16A and 16B of motor assembly 10. Reservoir 55 and optional oil cooler 60 are also connected to pumps 52 through a plurality of hoses 63 and 64 in the manner shown. Other arrangements could be used depending on factors such as vehicle size.

As is known in the art during operation of vehicle 50, one of hoses 62A or 62B will be under high pressure, and the other will be under low pressure or vacuum pressure, depending on the direction of actuation of pump 52, and this can be changed to change the speed and direction of output axle 34.

FIGS. 3-6 show a first embodiment of the motor assembly of this invention. In this embodiment, the external casing or housing for the assembly 10 comprises axle housing 1, motor housing 2 and the external surfaces of ring gear 23 and port block 15. A plurality of bolts 14 are used to secure axle housing 1 to motor housing 2, thus sandwiching the other elements between them. Port block 15, which may also be referred to as a port plate, may include a plurality of tabs 33 to aid in alignment and orientation with motor housing 2 during assembly. Ring gear 23 may also include a plurality of tabs 43 to aid in alignment of ring gear 23 with axle housing 1 and port block 15 during assembly.

An axial piston style hydrostatic motor 8 is mounted in motor housing 2; motor 8 comprises a plurality of pistons 5 and corresponding springs 4 and thrust washers 6 mounted in rotatable cylinder block 3. While the preferred embodiment is depicted as an axial piston motor, other styles of hydraulic motors could be used within this invention. In this embodiment, pistons 5 engage thrust bearing 7 which in turn is mounted in motor housing 2. Pistons 5 are of the spherically-shaped nose, and are often referred to as "bull pistons." Motor cylinder block 3 is rotatably mounted on a running surface 12 formed on port block 15 and drives motor output shaft 13. Bearings 9A and 9B, which are preferably needle bearings, are used to support motor shaft 13 within motor housing 2 and port block 15, respectively. A pair of hydraulic ports 29A and 29B are formed in port block 15 to hydraulically connect motor cylinder block 3 with inlets 16A and 16B through kidneys. Port block 15 includes at least two inlets 16A and 16B and an opening 32 to permit motor shaft 13 to pass therethrough. As is known, the rotational speed and direction of motor shaft 13 will depend on the input to inlets 16A and 16B. Port block 15 is preferably made of cast iron, although other materials such as aluminum or the use of a separate valve plate would also be acceptable.

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This invention uses a dual planetary reduction system, although it will be understood that other gear reduction systems could be used in the spirit of the invention. Carrier pins **18** are mounted in primary planet carrier **19**, and planet gears **17** are mounted on their respective pins **18**. As is known in the art, washers **26A** and **26B** and O-rings **24** are used as needed; FIG. **3** depicts various other retaining rings, springs and the like that would be typical in such an assembly.

Motor shaft **13** has a gear form **27** integrally formed thereon; it will be understood that this gear form **27** could also be a separate gear fixed to shaft **13**. Gear form **27** engages and drives primary planet gears **17**, which in turn cause rotation of carrier plate **19**. Sun gear **20** is engaged to the inner teeth of carrier plate **19** and transfers the rotational force through to secondary planet gears **21**, which in turn are mounted on pins **40** mounted on secondary carrier **22**.

As noted above, ring gear **23** also functions as part of the overall external housing for motor assembly **10** and provides an internal running surface for primary planet gears **17** and secondary planet gears **21**. Port block **15** can also serve as part of the external housing, as port block **15** and ring gear **23** are sandwiched between axle housing **1** and motor housing **2**. This arrangement, while not necessary to use the invention, reduces the amount of materials needed and the overall costs of the unit. The size of axle housing **1** and/or motor housing **2** could be increased to mount these elements internally.

Axle shaft **34** is supported in axle housing **1** by means of a needle bearing **28** and ball bearing **38** and is drivingly mated to secondary planet carrier **22**. Thus, the rotational torque of motor shaft **13** is increased through the two sets of planetary gears **17** and **21**.

It is understood that the shape of port block **15** is not essential, although there are benefits to the shape shown in FIGS. **3-6**, such as reduced cost, as noted herein. This element can also be referred to as a center section, end cap, plate or the like. A first drain passage **44** permits oil to flow from inside motor housing **2** to ring gear **23** and the rest of the assembly. A second drain passage **46** is also formed in port block **15** and permits oil to drain from the system through case drain **48** formed in motor housing **2**. Hose **64** connects case drain **48** to reservoir **55** by way of optional oil cooler **60**.

An alternative embodiment of the port plate is shown in FIGS. **7 to 11**, which shows port block **115** including optional pressure relief valves **35A** and **35B**, and wherein identical reference numerals indicate structure that is identical or substantially identical to that described for other embodiments. This feature is optionally used with the other features disclosed herein, or on its own. As shown in FIGS. **7 to 11**, port block **115** includes a pair of pressure relief valves **35** mounted in hydraulic ports **29A** and **29B**, respectively, and opposite to inlets **16A** and **16B**. The embodiment would also include drain passages, such as drain passage **146**. The relief valve **35** described herein is designed to close slowly after opening; it will be understood by one of skill in the art that other relief valve designs can be used in this design.

Pressure relief valve **35A**, which can be identical to valve **35B**, is shown in more detail in FIGS. **12 and 13**. FIGS. **10 and 11** show valves **35A** and **35B** schematically to avoid confusion caused by the differing cross-sectional perspectives.

Pressure relief ports **39A**, **39B**, **41A** and **41B** are formed in port block **115**. Looking at FIG. **10**, which is a cross-sectional view along the lines **3-3** in FIG. **7**, it should first be noted that line **3-3** is not straight, but rather breaks to pass through the center of both ports **41A** and **41B**, as port **41B** is slightly offset higher than port **41A** in the end view shown in FIG. **7**. When hydraulic port **29A** and kidney **30A** are under high pressure, hydraulic port **29B** and kidney **30B** are under low pressure,

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and the oil pressure in port **29A** causes valve **35A** to open. The rate at which valve **35A** opens and closes can be set through design changes such as the spring constant of spring **71** and the diameters of bore **76** and bleed orifice **78**.

When valve **35A** opens, oil will flow from port **29A** into relief port **41B**, and then to relief port **41A** and on to low pressure kidney **30B**. As can be seen in FIG. **11**, the same dampening action will occur when port **29B** and kidney **30B** are under high pressure, as valve **35B** will open to connect port **29B** to relief ports **39A** and **39B**, and then to low pressure kidney **30A**. This pressure relief acts to dampen the response of motor cylinder block **3** to sudden increases in pressure in the system to smooth out operation of the vehicle; placing the relief valves in the motor port block **115** instead of in the pump increases their effectiveness, as the dampening is moved closer to the ultimate output of the system, i.e., axle shaft **34**.

As shown most clearly in FIG. **13**, one of the valves **35A** or **35B**, designated here as valve **35**, consists of a valve body **66** which uses an O-ring **73** to prevent leakage out of the system. Spring **71** is mounted in bore **67** of valve body **66**, and engages outer plunger or cylinder **68**. A center piston **72**, which has an inner bore **76**, is mounted in inner bore **70** of outer cylinder **68**. Ball **69** is pressed into inner bore **70** at one end thereof. A separate seat **74** is pressed into hydraulic port **29** to a measured depth, or to a stop formed therein, and includes an opening **75** formed therein. Seat **74** could also be integrally formed with block **115**. Ball **69** could be replaced by other shapes or a functionally equivalent feature could be integrally formed in outer cylinder **68**.

Valve **35** is shown in the closed position in FIG. **13**. As the oil pressure outside seat **74** increases, oil will flow through seat opening **75** into bore **76** of piston **72**. The force of piston **72** against ball **69** will move cylinder **68** in the axial direction away from seat **74** compressing spring **71**, thus opening valve **35** and permitting high pressure oil to pass into the bypass porting as described above. Oil will also pass through bleed orifice **78** to the area **77** adjacent ball **69** inside bore **70**. As the oil pressure in area **77** increases, it increases pressure on piston **72**, forcing piston **72** to move axially away from ball **69** to the point where it again engages seat **74** and closes valve **35**.

Another benefit of this invention is that the design taught herein enables the user to locate neutral valves in the motor port block for applications where such valves may be desired. Neutral valves are known in hydraulic applications but generally have been located in hydraulic pumps or, in an integrated hydrostatic transmission, in the center section connecting the pump and the motor. FIG. **17** shows another embodiment of this invention, similar to that shown in FIG. **8**, where neutral valves **81** are mounted in port plate **215**; except as described herein, other elements of port plate **215** can be identical to those of port plate **115** described with regard to FIG. **8**.

Neutral valves **81** may be generally identical in construction and are mounted in hydraulic ports **229A** and **229B**. In the position shown, oil passes through passages **79** formed in valves **81** to openings **82** formed in ports **29A** and **29B**, to permit the hydraulic oil to drain to case. As system pressure in ports **229A** and **229B** increases, the valves will close.

It is often desirable, though not necessary, to include a brake on such a motor. A first brake design is shown in FIGS. **3, 4 and 6**, where a brake cam **31** and puck **42** are mounted inside port block **15**. Handle **36** is secured to cam **31** and may be rotated by means of an actuation mechanism (not shown). Puck **42** has a first, disengaged, position as shown in FIG. **6**. Rotation of cam **31** will cause puck **42** to move against and

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engage brake rotor 37, which is drivingly attached to output shaft 13, which in turn will force stator 25 against the end of ring gear 23 to brake the gear train. Spacer 45 fits around the outer diameter of brake rotor 37 and is used to prevent brake stator 25 from being pushed into rotor 37 and thus port block 15 when the brake is disengaged.

Further embodiments of the brake mechanism are shown in FIGS. 14-16. For example, FIGS. 14 and 15 show motor assembly 90 having a motor shaft 92 extending out of motor housing 95 and having a cog 94 secured thereto and which rotates with motor shaft 92 and has a plurality of teeth 94A and openings 94B. Handle 96 is actuated to engage cog 94 through the use of tab 97. Handle 96 is of a horseshoe design and rotates about the base 96A about an axis perpendicular to the longitudinal axes of motor shaft 92 or axle 93. A tab or other similar structure 96B is formed at the top thereof (or the side opposite the axis of rotation) to engage an actuation mechanism (not shown) to rotate the horseshoe handle 96 from the disengaged position, as shown in FIG. 14, to an engaged position where tab 97 is engaged with one of the openings 94B of cog 94, thus providing braking of motor shaft 92. FIG. 14 also shows case drain 148 located in port block 315, positioned on a side away from the inlets 16A and 16B. Another embodiment of this configuration would have case drain 148 positioned on the port block 315 on the opposite side from inlets 16A and 16B.

A further embodiment of the brake mechanism is shown in FIG. 16, which also has cog 94 mounted on motor shaft 92. The size and shape of cog 94, and its teeth 94A and openings 94B, will depend to a great extent on the size of the assembly, intended loads and similar factors, and may be adjusted accordingly. In FIG. 16, motor housing 85 is shaped to receive an optional cup-shaped cover 86, which may be secured thereto through screws 87 or similar means to bracket 84. A T-bar handle 88 having an engagement member 88A is mounted in bracket 84 and is rotatable about its longitudinal axis 88B from the disengaged position shown in FIG. 16 to the engaged position shown in dashed lines in FIG. 16. Cap 86 acts to locate T-bar handle 88, and gasket 83 and grommets 89 act to seal cap 86 from the outside environment.

The engagement of T-bar handle 88 to cog 94 provides braking force to motor shaft 92 and thus brakes the entire assembly. T-bar handle 88 is rotated into or out of the engaged position through an actuation mechanism (not shown) which would attach to the ends of T-bar handle 88. Other known actuation mechanisms could be used depending on the layout of the vehicle or other application where the assembly is to be used.

It is further envisioned that a spring (not shown) may be provided to maintain the engagement of handle 96 or handle 88, and the aforementioned brake actuation mechanism would thus act to disengage the brake to allow vehicle movement.

A further benefit of the design shown in FIG. 15 is that axle shaft 93 in this embodiment also extends to and is supported by motor shaft 92, through bearing 98. This shaft design is an optional feature and can be used with the brake design shown in FIG. 15 or any of the other embodiments described herein.

While specific embodiments of the invention have been described in detail, it will be appreciated by those skilled in the art that various modifications and alternatives to those details could be developed in light of the overall teachings of the disclosure. Accordingly, the particular arrangements disclosed are meant to be illustrative only and not limiting as to the scope of the invention which is to be given the full breadth of the appended claims and any equivalent thereof.

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What is claimed is:

1. A hydraulic motor assembly for use with a separate hydraulic pump, the motor assembly comprising:
 - a motor housing and a port block engaged to the motor housing, whereby the motor housing and port block cooperate to form a motor sump in which a motor cylinder block is mounted, the port block having a motor running surface formed thereon and hydraulic porting comprising a pair of passages formed therein;
 - a pair of kidneys formed in the motor running surface of the port block, wherein each kidney is in hydraulic communication with one of the pair of passages in the hydraulic porting and in hydraulic communication with the motor cylinder block;
 - a pair of externally opening inlets located in the port block, wherein both inlets are hydraulically connected to the hydraulic porting for providing hydraulic fluid from the separate pump to the hydraulic porting and a path for hydraulic fluid to return from the hydraulic porting to the separate pump; and
 - a first pressure relief valve located in the port block and providing a fluid path between the pair of passages.
2. The hydraulic motor assembly as set forth in claim 1, wherein the first pressure relief valve extends generally parallel to the externally opening inlets.
3. The hydraulic motor assembly as set forth in claim 1, wherein the externally open inlets are located on one side of the port block and the first pressure relief valve is located on an opposite side of the port block.
4. The hydraulic motor assembly as set forth in claim 1, wherein the first pressure relief valve is generally collinear with one of the pair of externally opening inlets.
5. The hydraulic motor assembly as set forth in claim 1, comprising a second pressure relief valve providing a fluid path between the pair of passages.
6. The hydraulic motor assembly as set forth in claim 5, wherein the second pressure relief valve is parallel to the first pressure relief valve.
7. The hydraulic motor assembly of claim 1, further comprising an axle housing engaged to the port block, wherein the port block is located between the motor housing and the axle housing.
8. A vehicle comprising:
 - a first hydraulic pump having a first pump housing;
 - a first hydraulic motor assembly hydraulically connected to the first hydraulic pump, wherein the first hydraulic motor assembly comprises:
 - a first motor housing located separate from the first pump housing;
 - a first port block engaged to the first motor housing and having a motor running surface formed thereon;
 - a first inlet and a second inlet formed in the first port block, wherein both the first and second inlets are open external to the first hydraulic motor assembly and are hydraulically connected to the first hydraulic pump;
 - a first hydraulic port formed in the first port block and connected to the first inlet and a second hydraulic port formed in the first port block and connected to the second inlet; and
 - a first pressure relief valve positioned in the first port block to control fluid flow between the first hydraulic port and the second hydraulic port.
9. The vehicle of claim 8, further comprising a second pressure relief valve positioned in the first port block to control fluid flow between the first hydraulic port and the second hydraulic port.

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10. The vehicle of claim 9, further comprising a second hydraulic pump having a second pump housing and being hydraulically connected to a second hydraulic motor assembly, wherein the second hydraulic motor assembly comprises a pair of pressure relief valves located in a second port block. 5

11. The vehicle of claim 10, further comprising an oil reservoir providing a source of oil for the first and second hydraulic pumps.

12. The vehicle of claim 11, further comprising an oil cooler connected to at least one of the group comprising the first hydraulic pump, the first hydraulic motor, and the oil reservoir. 10

13. A hydraulic motor assembly for use in connection with a separate hydraulic pump located in a pump housing, the hydraulic motor assembly comprising: 15

an axle housing;

an axle shaft mounted within and extending from the axle housing;

a motor housing located separate from the pump housing; 20

a hydraulic motor located within the motor housing and driving a motor shaft; and

a port block located between the axle housing and the motor housing, the port block comprising:

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first and second inlets opening external to the hydraulic motor assembly for connection to the separate hydraulic pump;

a first hydraulic port providing a hydraulic connection between the first inlet and the hydraulic motor;

a second hydraulic port providing a hydraulic connection between the second inlet and the hydraulic motor; and

a first pressure relief valve positioned in the port block to provide a fluid path between the first hydraulic port and the second hydraulic port.

14. The hydraulic motor assembly of claim 13, further comprising a second pressure relief valve positioned to provide a fluid path from the second hydraulic port to the first hydraulic port. 10

15. The hydraulic motor assembly of claim 13, wherein the motor shaft drives a plurality of gears that then drive the axle shaft. 15

16. The hydraulic motor assembly of claim 15, wherein the plurality of gears comprises a ring gear and an exterior portion of the ring gear is located between the port block and the axle housing. 20

17. The hydraulic motor assembly of claim 13, wherein the first pressure relief valve is generally collinear with the first inlet.

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